# THE FIELD AND LIMITATION OF THE OPERATIVE SURGERY OF THE HUMAN BRAIN.

[Continued from p. 22.]

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IX. The results of the study of cerebral localization are more necessary to the conscientious surgeon than to the neurologist.

If any of the cerebral functions are with certainty recognized as located in definite convolutions and regions of the cortex of the cerebral hemispheres; if it has been demonstrated that perforation of the skull and incision of the membranes and brain will at times prevent the destruction of life by intra-cranial inflammation, abscess or tumor; then it follows as a direct conclusion that a man, who assumes the role of a specialist competent to relieve disease by operative measures when medicinal therapeutics become impotent, must, if he is conscientious, make the subject of cerebral localization an object of study. I hold that such study is more necessary to him than to the neurologist, though the latter may, and probably does, need a more detailed knowledge of the subject. The surgeon, when called upon to decide as to the propriety of operation, is often, and indeed usually, the sole authority by whom the question must be determined. If operation is required in these cases, it is required at once; no time can be wasted in waiting for the services of a neurologist living in a distant part of the county or state. Often, moreover, time to consult books is scarcely available. Therefore, as many cerebral functions *have* been definitely localized and many cases *have* shown that life can be saved by perforation of the skull and incision of the membranes and brain, I hold that the study of cerebral localization *is* more important to the conscientious surgeon than to the neurologist, who is seldom called upon to determine such questions in haste, except when the surgeon finds his own knowledge deficient.

Reference to a few of the cases in which cerebral localization or functional cerebral topograpy has been well utilized in surgical practice is here proper. Afterwards, I shall detail some of the facts which experimental and clinical investigation have proved to be of value to surgeons.

The recent removal by Godlee of a gliomatous tumor of the size of a walnut from beneath the gray matter of the upper part of the ascending frontal convolution has probably attracted the notice of you all.[1]

The patient died, after the expiration of four weeks, from meningitis, which it is possible may have been due to inefficient drainage of the wound, as I have seen no statement that drainage was provided. The chief symptoms which led Dr. Hughes Bennett, who had charge of the case, to diagnosticate the extent and locality of the tumor were paroxysmal twitchings of the left side of the face, alternating with twitchings of the left hand and arm followed by slowly progressive paralysis of the hand, and later by twitchings of the left leg and eyelid and paresis of the left leg. These symptoms were accompanied by double optic neuritis and violent headache. Dr. Bennett concluded that there was a brain tumor involving the cortical substance of the right hemisphere; that it was probably of limited size, as it had destroyed the centres presiding over motion of the hand, but had not yet destroyed the centres of the leg, face and eyelids; and that to reach it trephining should be done at the upper third of the fissure of Rolando. The operation was performed and the tumor readily removed. The lancinating pains in the head, the vomiting, the twitchings of the limbs, were relieved; up to the 20th day, the temperature was never over 100°, the pulse not above 90, and the patient was perfectly intelligent. Death, however, occurred on the 28th day after rigor; fever and pain had occurred during several days preceding.

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[1] *Lancet*, December 20, 1884, and January, 1885. See also *Annals of Surgery*, St. Louis, March 1885, for Dr. Amidon's review of the case.

It has been stated[1] that Macewen, of Glasgow, has twice successfully removed foreign growths of which the site had been determined by the principles of cerebral localization. Other successful operations for localized purulent and hemorrhagic exudations similarly detected have been attributed to the same surgeon. He recently wrote me that he had not yet put the records of his cases in print, and that the accounts which had already appeared of some of them were not very trustworthy, but that he shortly intended to publish all of his cases bearing on this point. We are still, therefore, without any authoritative statement of the details of his operations. Broca, Lucas-Championnière, E. C. Seguin[2] and E. C. Fuller[3] have given careful attention to, and valuable clinical information upon, the subject of cerebral topography in its surgical relations.

Dr. M. Allen Starr has given[4] a valuable analysis of American cases in which there existed localized cortical lesions of the brain. Some of these cases are surgical, others medical, but the two papers deserve the careful perusal of every surgeon.

The following case of operation from the unpublished notes of Dr. Charles K. Mills, and furnished by his resident physician, shows very distinctly the value of cerebral localization.

*Epilepsy following cranial traumatism: Situation of meningeal lesions diagnosticated by the principles of cerebral localization: Trephining: Death.*

A man. aged about 40 years, without any personal venereal history, and belonging to a family without any epileptic history, had, it was said, excellent health until eleven years before he came under Dr Mills's observation. At that time, in 1873, he was struck upon the head many times with a boot-jack, and the mother was told by a physician that the skull was crushed through the skin was not lacerated. Consciousness was not lost at the time of the injury. Great swelling of the parts followed immediately, and there occurred intense headache, which was almost constant, though much worse at times than at others. This was soon succeeded by attacks of vertigo, which sometimes resulted in his falling to the ground; consciousness, however, was retained. These attacks increased in severity until about three years after the receipt of injury, when he first began to suffer with true epileptic paroxysms, chiefly petit mal. The convulsions were slight or wanting, and unconsciousness lasted only a short time. The mother states that once a month he would have from three to six fits, after which he would be exempt from them until the next change of the moon.

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[1] *Boston Med. and Surg. Jour.*, January 15, 1885.

[2] *Archives of Medicine*, December, 1882.

[3] *Archives of Medicine*, Vol. IX., p. 262, 1884.

[4] *Amer. Jour. Med. Sciences*, April and July, 1884.

The seizures gradually increased in severity and number during the eight years following his first paroxysm. During all these years he suffered with headache, which was always located at the seat of injury, which at times was so intense as to cause him to throw his hand to the seat of pain, and run and bury his head in his mother's lap.

About the time he first began to lose consciousness during the attacks (three years after injury) his eyesight rapidly began to fail, and he entered the Wills Eye Hospital, where he remained a short time. Previous to his death he was only able to see the name of the paper on a newspaper, and partly on this account, as well as on account of his headache, he seldom went out unattended by his mother. During the past weeks he appears to have suffered more than usual from his headache, which was described as a throbbing at the seat of the former injury, and his epileptic paroxysms came on him more frequently and were of a more convulsive character. His mother states that he would never bite his tongue during the convulsion, but that there would be some frothing at his mouth, and that his jaws would be fixed.

Five or six days before entering the Philadelphia hospital, he first noticed a weakness of the right arm, and a little later of the leg on the same side (the seat of injury being the left). About two days later he was unable to raise his arm, and in walking dragged his right leg. His mother does not know whether there was a disturbance of sensibility on the affected side or not.

His mother states that the convulsions followed each other at intervals of about half an hour, and that between them his mental condition had been the same as it was when Dr. Free, resident physician, found him on arriving in the ambulance. He was at that time lying on the floor, almost nude, in a maniacal condition, constantly repeating "I did not do it," all the while throwing his left hand up over the left side of his head, and then again down to his side or over his abdomen. His right arm and leg he did not move. The jolting of the ambulance seemed to promote his paroxysms, as he would have them every five minutes.

On arriving at the hospital he was given 80 grs. of bromide of potassium, but with no effect. Nitrite of amyl was tried, but was found equally useless. Then inhalation of ether during the paroxysms, with hypodermic injections of morphia and atropia were administered, which shortened the attacks. During the convulsion the left arm was in a state of rigidity and the fingers clinched. There was also marked clonic spasm of the arm and leg of the right side, alternating with some rigidity. The spasm in the right side differed from that in the left in being both clonic and tonic. The eyes were fixed, deviating to the right side, and the pupils very much dilated, the left slightly more so than the right; especially was the latter fact noticeable between the paroxysms. In the intervals his eyes showed a beautiful example of horizontal oscillation. This was bilateral, and the eyes acted together with perhaps a slight internal strabismus. Pulse very irregular, ranging from 100 to 160. His convulsions during the night followed each other at regular intervals of from 13 to 15 minutes, and if they were anticipated by inhalation of ether would be postponed until the end of the next 15 minutes.

About midnight he began to use his arms less wildly, his paroxysms occurred at longer intervals, and his pupils, which before had been widely dilated, contracted almost to pin head size, but dilated during the paroxysms. Respiration was impeded or almost arrested after the convulsions, but never became stertorous. He passed very little urine. He became comatose, and remained so until June 5th, 5 P. M.

At this time the patient was first seen by Dr. Mills, and in consultation with Dr. Hearn it was decided to trephine. Although the mother stated that the injury was on the left side of the head, well forward, it was not indicated by any scar; but Drs. Mills and Hearn decided to trephine on the left, about the Rolandic line, concluding that the convulsions on the left were due to involvement of the dura mater, while those in the right to cortical irritation of left hemisphere, in addition to the dural spasms.

The operation was done without the aid of an anæsthetic, and a piece of the skull removed. The dura mater was found rather more injected than was normal, and slightly adherent to the portion removed. No depression or fracture of the internal table was apparent. Soon after the operation he became quieter, his convulsions less marked, and he was again able to swallow and take a little nourishment during the night.

On the morning after the operation he spoke a few words intelligibly, and recognized his mother.

Nourishment was given him both by stomach and rectum, as he could retain but little in his stomach. His convulsions during the day and night were slight, and involved both sides. June 7th and 8th, second and third days after operation, it was evident that the man was becoming weaker, h s pulse more feeble and rapid, but his temperature not much above normal; his breathing was hurried, but not stertorous, and he slept a considerable portion of the time. On the second day he had about six convulsions and but four on the third. On the night of June 8, 80 hours after the operation and four days and a half after beginning of his attack the man died without a struggle, having had no convulsion during the night.

Autopsy held 13¾ hours after death.

Scalp wound the result of trephining, which had been performed June 6, 1884.

On the left side, at the seat of operation, the dura mater of convexity of left hemisphere, at a point one-fourth inch in front of fissure of Rolando and forward, was firmly adherent to pia mater and substance of the brain. The tissues as a whole formed a common mass. The dura mater was adherent to the skull over the anterior portion ot this area, and was also very firmly adherent at base on left side under the middle lobe.

The trephining had been over the seat of meningitis. The dura mater was much detached, particularly over the anterior frontal lobe, and adhered beneath to the gray and white matter.

Membranes showed necrobiotic spots.

Cause of death, pachymeningitis.

Although this dying man's life was not saved by operation, the seat of disease was determined by the symptoms, which was an important matter, since no scalp lesion or accurate clinical history pointed to the exact region of injury. Dr. Mills looks upon the case as one of meningeal disease induced by an injury, causing sub-cranial extravasation without fracture, which resulted in secondary meningitis, leading to adhesion. It is given here as an example of the value of localizing symptoms.

Enough is shown by these cases to prove the distinct surgical value of the study of cerebral localization, despite the opinion of one of our most distinguished members, who in 1882, after speaking of the investigations of Broca and Lucas-Championnière, said: "I hope that I may be pardoned for expressing the opinion that their interesting investigations are more ingenious than practically useful."[1]

I shall, therefore, devote a little time to the discussion of the means by which the location of the cerebral convolutions important to surgeons may be marked on the shaven head.

The head must be so placed that a line drawn from the alveolar process of the upper jaw at the base of the incisor teeth to the lowest part of the occipital bone, will be horizon-

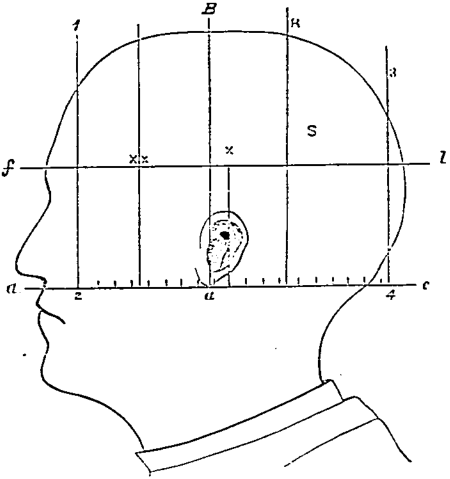

FIG. I. OUTLINE OF HEAD, REDUCED ONE-THIRD, ON WHICH A MODIFIED SYSTEM OF FÉRÉ'S LINES IS DRAWN.[2]

*AC*, alveolo-condyloid; *AB*, auriculo-bregmatic line; *FL*, fronto-lambdoidal line; 1, 2, frontal limit; 3, 4, occipital limit of the brain; *R*, posterior extremity of the fissure of Rolando; *X*, anterior extremity, same; *XX*, location of the middle fold of the third frontal convolution, a little below and in front of which lies the tip of the sphenoidal lobe; *S*, the posterior extremity of the fissure of Sylvius, and the intersection of the lines 3. 4, and *FL*, locates the occipital fissure.

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[1] *Ashhurst, Principles and Practice of Surgery*, p. 326.

[2] Amidon, "Surgical Interference in Affections of the Brain." *Medical News*, June 21, 1884.

tal. Ranney[1] says the line or plane is easiest drawn in the living subject from the cusps of the teeth to the tip of the mastoid process. This alveolo-condyloid line is the base line from which other measurements are made. A perpendicular line drawn upwards from the alveolo-condyloid line through the external auditory meatus corresponds at the top of the skull with the transverse plane running through the bregma or point of intersection of the sagittal and coronal sutures. This line is called the auriculo-bregmatic line. The location of the bregma which, of course, lies in the median line of the head is thus determined.

Sometimes the bregma, which is the anterior fontanelle of infancy, can be felt through the scalp of adults; if it can not be so distinguished the ready methods of Broca or Lucas-Championnière may be employed instead of the mathematical one just described. A draughtsman's square of flexible material, such as steel, copper, or tin, which has at the intersection of the arms a conical plug to go into the auditory meatus, may be used. The plug is to be placed in the ear, the horizontal arm bent until it lies across the upper lip, directly under the columella of the nose, and the vertical arm then bent over the top of the head. The bregma is at the point where the axis of this vertical arm crosses the median line of the skull. This will probably give the situation of the bregma more accurately than the original Broca square, which, according to Lucas-Championnière,[2] had the ear-plug a little behind the intersection of the arms. The other method of locating the bregma is to cut a section out of a sheet of pasteboard so that it will sit astride of the shaven head from auditory meatus to auditory meatus. In order to insure the pasteboard being perpendicular to the alveolo-condyloid line, a lead pencil or stick is thrust at right angles through the pasteboard on a level with the eyes. This enables the surgeon to detect any error in the horizontal position of the base line of the head. The centre of the arch in the card-board is over the bregma.

The fissure of Rolando of each cerebral hemisphere, which is the most important cerebral sulcus concerned in our present studies, has its upper end about 5 centimetres behind the bregma, but does not run quite up to the middle line. Some writers give 4.5 centimetres, others 5.5 centimetres. Its lower end lies about 0.5 centimetre behind the auriculo-bregmatic line and a little above a horizontal line, parallel to the alveolo-condyloid line, carried backwards from the superciliary ridge. This would place the lower end of Rolando's fissure about 6 centimetres above and a little behind the external auditory canal. Another method of fixing the lower end of the fissure of Rolando is to draw a horizontal line, that is a line parallel to the alveolo-condyloid line, from the external angular process of the frontal bone, where it begins to curve upwards to form the temporal ridge. At a point 7 centimetres distant from the anterior extremity of

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[1] *Applied Anatomy of the Nervous System*, p. 69.

[2] *Trépanation Guidée par les Localisations Cérébrales*, p. 112.

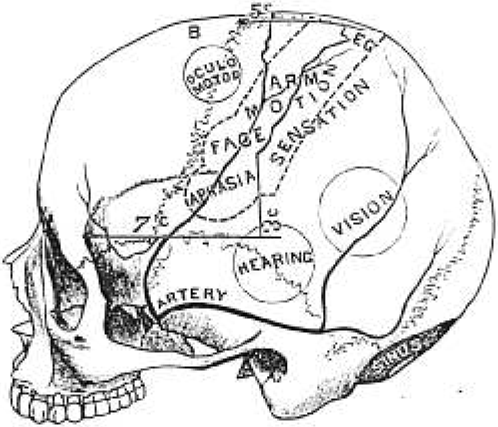

FIG. II. DIAGRAM OF THE EXTERIOR OF THE SKULL.

Upon this have been indicated the measurements for determining the position of the fissure of Rolando; and the location of the regions under which lie the centres of motion and sensation, as well as those of vision and hearing, and the oculo-motor centre. The position of the grooves for the two branches of the middle meningeal artery and for the lateral sinus are also shown.

this line draw a perpendicular line extending upwards 3 centimetres. The end of this last line is over the lower end of the fissure of Rolando.

Erichsen quotes Thane[1] as follows: "The upper end of the sulcus of Rolando is placed about half an inch behind a point midway between the root of the nose and the external occipital protuberance, its lower end is close to the posterior limb and about an inch behind the bifurcation of the fissure of Sylvius. The bifurcation of the fissure of Sylvius corresponds to a point one inch and a quarter behind and a quarter of an inch above the level of the external angular process of the frontal bone."

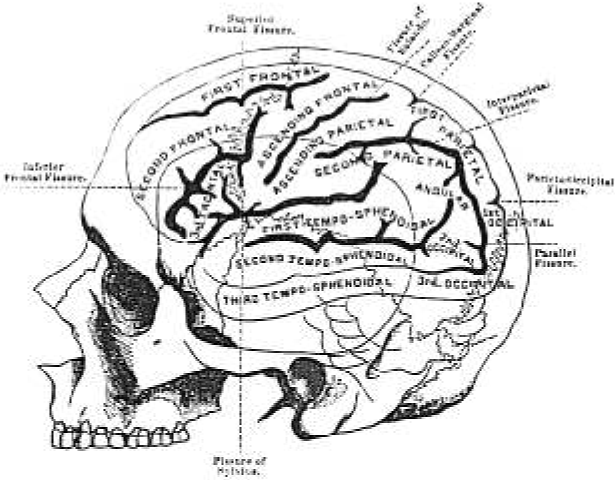

FIG. III. THE CHIEF CONVOLUTIONS AND FISSURES ON THE EXTERIOR OF THE CEREBRUM, (DIAGRAMMATIC).

The occipito-parietal fissure corresponds nearly with the lambdoidal suture at the median line.

After the location of the fissure of Rolando has been marked, as with an aniline pencil, on the scalp, it is easy to locate the cerebral convolutions which control the movements of the opposite half of the head, body and limbs.

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[1] "*Science and Art of Surgery*, I., p. 731.

"The first or superior frontal convolution will be found commencing about 2.5 centimetres behind the bregma, and passing forward near the median line toward the orbit. The second frontal convolution will occupy a similar but more lateral position, while the third frontal convolution lies wholly in front of the auriculo-bregmatic line and on a plane 5 centimetres above the external auditory meatus. Its folded or central part is about 2.5 centimetres in front of the auriculo-bregmatic line, or about 2 centimetres behind the external angular process of the frontal bone."[1]

I have now shown how we can outline upon the scalp the situation of the cerebral convolutions. Hence, if we find symptoms which are known to be produced by lesions of certain regions of the cortex of the brain, it becomes our duty to trephine over the region indicated, provided that the symptoms are sufficiently particularized to indicate that a moderate, I do not say small, area of the brain is affected by disease. Inflammation, abscess or tumor, while circumscribed, will give a localized group of symptoms; soon, however, secondary œdema, inflammation, or softening may occur, and by affecting other areas of the brain will give additional symptoms. These secondary or indirect local symptoms will render accurate delineation of the seat of lesion difficult. Cases therefore should be studied accurately and carefully by competent observers at an early period, before the symptoms became more general, through advancing disease, and the relief possibly derivable from operation diminished.

Cerebral localization is as valuable when informing us to abstain from operation, as when telling us that speedy operation is demanded. Loss of motion, or motor paralysis, is the symptom that has been chiefly depended upon as a localizing symptom in surgery; because it is more easily observed and has been more carefully studied than loss of sensation, or sensory paralysis, and the other cerebral functions. The area about the fissure of Rolando is that in which the motor centres for the face and limbs have been found by physiologists and neurologists. It is necessary, therefore, to study these in more detail. As physiological knowledge increases the sensory area of the brain will, in all probability, become equally important to surgeons.

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[1] Amidon, *Medical News*, June 21, 1884.

I have formulated the most important facts, according to recent physiological research, in order that the bearing of the corresponding surgical questions may be understood. The progress of knowledge may overthrow some of my conclusions, but that they are quite justified by present knowledge I think undoubted. The physiological portion and the tables which immediately follow have been submitted to my colleague, Dr. Chas. K. Mills, who, while not responsible for my statements, has kindly given me valuable suggestions. In order to use these facts a general diagnosis of a cortical lesion, that is, of a lesion not of the ganglia or tracts, must first be made.

*Motion.* The gray matter of the ascending frontal and ascending parietal convolutions, which are separated from each other by the fissure of Rolando and which coalesce over the top of this fissure in the paracentral lobule, is the portion in which are chiefly located the motor centres of the muscles of the face, tongue, arm, and leg, of the opposite side of the body, although the motor zone may extend forwards or backwards slightly beyond the strict limits of these convolutions. Some few nerve fibres are in relation with the muscles of the same side, but nevertheless in fully 90 per cent. of lesions of the cortical centres the anomalies of motion, namely, spasm and paralysis, occur on the side opposite to that in which the brain lesion exists. This statement is subject to modifications to be presented when speaking of the role of the dura mater. These ascending convolutions are conveniently spoken of as the central region.

The motor area for *face* and *tongue* lies in central region *lower 3d;* for the *arm*, central region, *middle 3d;* for the *leg*, central region, *upper 3d.*

In these areas are the centres for the individual muscles of said limbs, face, and tongue.

Spasm of one of these groups of muscles indicates irritation of the corresponding motor area in the brain cortex.

Paralysis of the same group of muscles indicates destruction of the same motor area.

Spasm or paralysis of two of these groups indicates that the lesion involves more than one area; for example:—Paralysis of one side of the face and of the corresponding arm indicates a destructive lesion of the lower and middle thirds of the central region; paralysis of the arm and corresponding lower limb points to a destructive lesion of the middle and upper thirds of the central region. Spasm would indicate similarly located irritative lesions.

Paralysis of face, arm, or leg (hemiplegia), would indicate destructive lesion of the lower, middle and upper thirds of the central region, and spasm of the same muscles, irritative lesion of all three portions of the central regions, except that it must be remembered that a primary lesion of one area sometimes affects secondarily the neighboring area or areas and causes hemiplegia. This is explained by several facts, among which are these:

The blood supply to the central region comes entirely from the middle cerebral artery which ascends in the pia mater upon the surface of the convolutions from the base in the vicinity of the island of Reil. Hence a lesion in a lower area may cause secondary symptoms in the area or areas above by cutting off its arterial supply.

The nerve fibres converge as they pass inwards from the cortex to make up the bundles traversing the interior of the brain in their journey to the muscles. Hence a lesion whose influence extends, by pressure or otherwise, below the surface a short distance, may implicate converging fibres coming from surrounding cortical areas, and thus give results such as would occur if these more distant cortical areas were really involved.

These and other facts explain the occurrence in some cases of hemispasm or hemiplegia, or of extensive spasm or extensive paralysis from limited lesions. If the lesion be a small focus of disease, thus giving rise to extensive spasm or paralysis it usually will first cause symptoms in the group of muscles supplied from the small area primarily affected, or the symptoms in that group will be more marked than in those secondarily involved. This point is of diagnostic importance. Hence the relative time of occurrence of symptoms always demands careful investigation.

When monospasm or hemispasm is one of the consensus of symptoms, the seat of the primary lesion may often be determined by study of the character of that spasm; especially by attention to the special muscles in which the spasm began. It is likely to be in that part of the cortex which is the area of control for this special group of muscles.

Paralysis of groups of muscles following spasm of the same, is characteristic of disease of the central region.

Seguin suggests that a hemiplegic state may be discovered, at least in some cases, by an increase of peripheral temperature, as of fingers or toes, on one side, or by the presence of congestion or erythema on one buttock.[1]

This may be valuable in diagnosticating cerebral hemorrhage from alcoholic coma and similar affections.

*Sensation.*—Late observation and experiment have proved that disturbance of general sensation, also, is one of the direct local symptoms of lesions in the central region. These disturbances include the senses of touch, pressure, pain and temperature, and the sense of location of a limb; and may consist in impairment of these functions or the perception of such sensations when there is no objective cause to produce them (hallucinations of sense).

General sensation then, is located in the central region, and especially it would seem in the portion behind the fissure of Rolando, that is, the ascending parietal convolution. It must not be forgotten, however, that the sensory region seems to include also the parietal lobes which lie behind the ascending parietal convolution, and which, it will be observed, contain but few motor centres and fibres.

The motor and sensory regions thus seem to overlap; for lesions in front of the fissure of Rolando have caused sensory, as well as the usual motor disturbances, and we have seen that motor disturbances may be due to lesion behind the fissure of Rolando in the ascending parietal convolution, where I have just said sensory areas exist. It is possible that future and more accurate investigation will show that the motor region is particularly located in front of the fissure of Rolando, but extends on the posterior side of the fissure, overlapping, or fading, into the sensory region behind the fissure, in a manner similar to that in which the motor areas for the arm and leg appear to overlap or fade into each other. It is more probable, perhaps, that we have not yet sufficiently defined the exact boundaries, because our methods of investigation are not sufficiently accurate. As is the case with the motor centres, which are connected especially with the opposite side of the body, so is it with the sensory centres; though a few sensory fibres go, as do a few motor fibres, to the same side of the body. Hence, sensory lesions give more marked sensory disturbance on the side opposite the lesion, and effect in a less degree the side corresponding to the lesion.

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[1] *Gross, System of Surgery,* Vol. II. p. 44.

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| The sensory area for the *face* probably lies in the central region *lower* third. | and probably behind the fissure of Rolando in the ascending parietal and parietal convolutions. |
| The sensory area for the *arm* probably lies in the central region *middle* third. | |
| The sensory area for the *leg* probably lies in the central region *upper* third. | |

Hyperæsthesia, pain, or paræsthesia of the face, arm or leg indicates irritation of the corresponding sensory area in the brain cortex.

Anæsthesia and analgesia indicates destruction of the corresponding sensory area in the brain cortex.

Hyperæsthesia or anæsthesia of two cutaneous tracts indicates that the lesion involves more than one area; for example: Anæsthesia of one side of the face and of the corresponding arm indicates a destructive lesion of the lower and middle third of the central region, probably situated behind the fissure of Rolando, and also in the parietal convolutions. Anæsthesia of the arm and corresponding lower limb, points to a destructive lesion of the middle and upper third of the central region, probably situated behind the fissure of Rolando, and also in the parietal convolutions. Hyperæsthesia would indicate similarly located irritative lesions.

Anæsthesia of face, arm and leg (hemianæsthesia) would indicate destructive lesion of the lower, middle and upper thirds of the central region, probably situated behind the fissure of Rolando and in the parietal convolutions; and hyperæsthesia of the same cutaneous tracts, irritative lesion of all three portions of the central region, probably situated behind the fissure of Rolando and in the parietal convolutions.

If motor paralysis is associated with these sensory disturbances in a cortical lesion, the probability is that we have a lesion involving both the ascending and the parietal convolutions. If the motor paralysis is slight, the lesion probably predominates in the parietal lobule.

*Loss of the Special Senses.* In localizing brain lesions by impairment of the special senses, it is important to eliminate all lesions occurring between the cortical centre and the sense organ. For example, loss of sight in brain disease may be due to an increase of intra-cranial pressure from a tumor causing choked disk, or loss of smell to pressure of a growth on the olfactory nerves after they leave the base of the brain. Such sources of error must be eliminated. This often requires careful study of the case.

Hemianopia, failure to recognize or remember familiar objects, or hallucinations of vision indicate disease probably in the occipital lobes, not far from the angular convolution. If the failure of sight includes the whole field of vision, both hemispheres are involved; if hemianopia only is present, one hemisphere is involved. Blindness of the right half of both eyes, that is, obliteration of the right half of the field of vision, indicates destructive lesion of the left occipital lobe, though it is the *left* half of the retina which is impaired. Hemianopia on the left side means lesion of the right side of the brain.

Deafness in one ear, or hallucinations of hearing on one side (such as voices and music), indicate disease of the first temporo-sphenoidal convolution of the opposite side. Failure to recognize or remember spoken language indicates lesion of the left first temporo-sphenoidal convolution in right-handed persons and of the right first temporo-sphenoidal convolution in left-handed persons.

Loss or hallucination of smell possibly indicates disease at the base of the brain in the temporo-sphenoidal region, which could not readily be reached by surgical procedures.

Loss of taste has not been sufficiently studied to afford even the suggestive evidence that we possess about disturbances of smell.

*Disturbances of other conscious mental actions*, such as judgment, reason and self control, will be exhibited in changed disposition and character of the patient. Such change, if no other general or localizing symptoms exist, indicates disease of the frontal lobes.

*Aphasia.* Disturbance in speech power, indicates disease in the neighborhood of the fissure of Sylvius, on the left side in right-handed persons, on the right side in left-handed persons. It must be recollected that neurologists distinguish three kinds of aphasia. Aphasia may be due to loss of—

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| 1. Memory of words (sensory aphasia). | Whose centre is situated in the first temporo-sphenoidal convolution. |
| 2. Memory of voluntary acts necessary to speech (motor aphasia). | Whose centre is situated in the posterior part of the third frontal convolution and lower part of central region (ascending frontal convolution.) |
| 3. Connection between the regions just described, which is required to turn thought into speech (aphasia of incoördination). | This function is located in fibres passing through island of Reil. |

There is some difference of opinion between French and German writers as to the distribution of these centres, but for our surgical purposes the assertions above given are sufficiently accurate. It will be seen that the convolutions mentioned are in close anatomical relation. I have followed, on this point and in many other respects, the elaborate resumé of Dr. Starr, who has analyzed a large number of reported American cases.[1]

If the patient understands a question, and can recall the words for a reply, but cannot make the requisite speech movements, he has motor aphasia, which indicates disease in the third frontal and lower end of the ascending frontal convolutions.

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[1] Cortical Lesions of the Brain, by M. Allen Starr, *American Journal Medical Sciences*, April and July, 1884.

If he cannot recognize spoken language, but is able to repeat words after another person, or can use exclamations on being annoyed, he has sensory aphasia, which indicates disease in the first temporo-sphenoidal convolution.

If he can understand and talk, but puts an unexpected word for the one desired, he has aphasia of incoördination, which indicates disease situated deeply within the Sylvian fissure or in the island of Riel and the white substance thereabouts, and involves the association fibres.

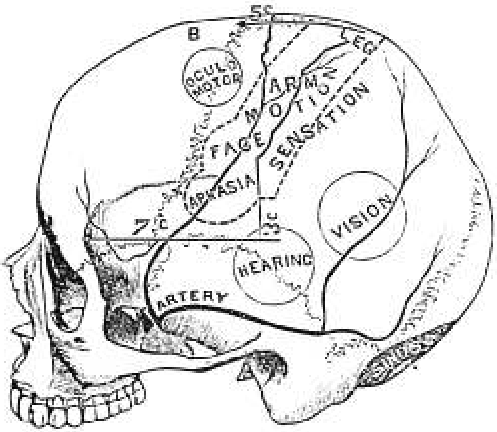

FIG. II. DIAGRAM OF THE EXTERIOR OF THE SKULL.

Upon this have been indicated the measurements for determining the position of the fissure of Rolando; and the location of the regions under which lie the centres of motion and sensation, as well as those of vision and hearing, and the oculo-motor centre. The position of the grooves for the two branches of the middle meningeal artery and for the lateral sinus are also shown.

These points need further study, I admit, because all authorities do not exactly concur in these locations; but the difference is not enough to disturb the question of operation. When opening the skull, in the search for abscess or tumor located by localizing symptoms, the surgeon should use a large trephine, because the exact spot of lesion is not determinable.

From a study of the points just discussed, and the writings of Lucas-Championnière[1] and A. L. Ranney,[2] I present the following deductions concerning the proper points for operation when lesions amenable to operative treatment have been distinguished and localized by the symptoms exhibited. It must be remembered, however, that I am treading very often on debatable ground, and have made statements which from increase in knowledge may require modification in a few weeks or months. I have endeavored to be categorical, and at the same time to indicate by my phraseology those opinions and logical positions which are most satisfactorily and certainly proved to be correct.

The researches of H. Duret,[3] who has shown that some motor symptoms may be due to traumatic irritation of the dura mater, must not be forgotten in studying individual cases. The non-correspondence of the symptoms, observed in a given case, with the typical symptoms described as accompanying a lesion in that locality, may be due to a dural lesion, in addition to the cortical lesion; and on the other hand, certain observed symptoms may be caused by dural, rather than cortical lesions. These questions are too intricate to be further discussed at this time, but must be indicated by me, in order that I may not deceive you into believing that cerebral localization is an easy problem in all cases of brain injury or surgical disease.

Duret says the dura mater contains sensory nerves eminently excitable, and that

"I. Irritative lesions of these nerves cause,

"1. Pain, hyperæsthesia, neuralgia and reflex motor phenomena.

"2. Reflex spasms or contractures of the muscles of animal and organic life.

"(*a*) The spasms or contractures of the muscles of animal life may occur in the face, eye-balls, neck, trunk or limbs. They occur sometimes on one side, sometimes on the other."

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[1] *Trépanation Guidée par les Localisations Cérébrales.*

[2] *Applied Anatomy of the Nervous System.*

[3] On the Role of the Dura Mater and its Nerves in Cerebral Traumatism. See *Brain* (1878), Vol. I., p. 29.

[This is to us an important item.] "These symptoms tend to diffuse and invade neighboring groups of muscles. They have never the localization, the measured and purposed character of the contractions which belong to the lesions of the cortex. They frequently become transformed into permanent contractures.

"(*b*) The reflex vasomotor disturbances, due to irritation of the nerves of the dura mater, consist in spasms or congestive paralysis of the cerebral and ocular vessels, either on the same or the opposite side.

"These facts are important to pathologists, as they show the great influence of irritation of the nerves of the dura mater on cerebral vascular conditions, and on the organs of sense, and on the causation of secondary effects in cerebral traumatism, *i. e.*, on the congestions and inflammations of the cerebral membranes.

"II. Destructive lesions cause local anæsthesia of the dura mater."

I have made this long quotation from Duret because of its importance.

[To be Continued.]

# AN EXPERIMENTAL AND CLINICAL STUDY OF AIR EMBOLISM.

[Continued from page 50.]

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## EXPERIMENTS ON VENOUS AIR EMBOLISM.

THE injection of air was always made into the jugular vein. The neck was shaved and the surface disinfected with a 5 per cent. solution of carbolic acid. Ether was always used as an anæsthetic, the animal being kept fully under its influence until everything was in readiness to throw in the air, when the inhalation was suspended and the animal was allowed to come out from under its influence, for the purpose of studying the effects of the air on the heart and respiration,